AD-A124 994 BOILER CONTROL SURVEY REPORT(U) ULTRASYSTEMS INC IRVINE CA FEB 83 NCEL-CR-83.012 N62474-81-C-9388 1/1

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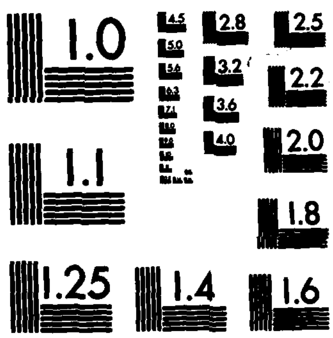

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NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California

Sponsored by
Navy Energy and Natural Resources R&D
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BOILER CONTROL SURVEY REPORT

February 1983

An Investigation Conducted by
ULTRASYSTEMS, INC
2400 Michelson Drive
Irvine, California

N62474-81-C-9388

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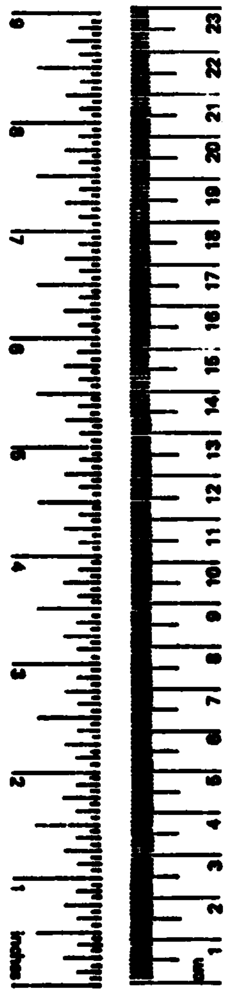
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

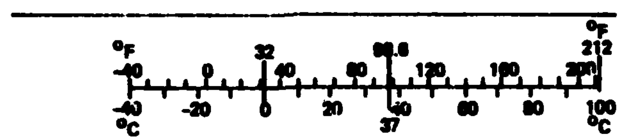
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Report presents results of survey of types of boiler control systems in use in Naval shore facilities.

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1.0 SUMMARY

The objective of Task 0 was to determine the types of boiler control systems currently in use at government owned facilities, and to identify the basic operating concepts of each system. It was originally intended to provide a breakdown of control system types by manufacturer and date of use. Bailey, Hagan, Hays, Republic, and Cleveland systems were to be identified for each of three time periods: 1940 to 1959, 1960 to 1975, and 1975 to present. However, as the study progressed, it was found that this approach was clearly not practical.

It was decided after discussion with the Naval Civil Engineering Lab at Port Hueneme, that the three most commonly employed operating concepts, jackshaft, pneumatic and electronic, would be examined. Logic diagrams, functional schematic diagrams and a brief operating description were prepared for each type of system.

2.0 Study Methodology

In order to provide pertinent conceptual design information relating to existing boilers, it was necessary to (1) determine the types of control systems which were the most prevalent, and, (2) identify the design concepts which governed those systems. The first of these objectives was met by means of a mass-mailing survey in which over 200 questionnaires were sent to facilities with boilers in the appropriate size range. The second objective was met through extensive discussions with control systems manufacturers and a thorough examination of vendor and in-house data.

2.1 Boiler Survey

The first step in this task was to determine the types of control systems currently in use. To accomplish this, the Ultrasystems FEUDS System[1] was reviewed to find the location and mailing addresses of all government operated boiler facilities in the U.S. Questionnaires requesting pertinent boiler data were then mailed out to each facility, along with a letter explaining the purpose of the questionnaire. A period of 5 weeks was allowed for the return of the questionnaires. Approximately 25 percent of the questionnaires were returned within the allowed time period. This is considered to be a typical response ratio for this type of survey.

[1]The Facility Energy Utilization Data System (FEUDS) is a computerized energy utilization data base which was developed by Ultrasystems, Inc. It was originally derived from the U.S. Environmental Protection Agency National Emissions Data System, and has been subsequently augmented and expanded by Ultrasystems. This data base currently contains over 238,000 point sources at 54,000 different facilities.

2.1 Boiler Survey, cont.

In addition to the above survey, pertinent data on a considerable number of boilers was also obtained from a Department of the Navy Boiler and Boiler Control Systems Data Base furnished by the Port Hueneme Naval Facilities Engineering Command. The data from the two sources was screened to avoid duplication and to eliminate those facilities which did not have boilers in the appropriate range. Boilers having a gross heat output of 30 to 100 million British Thermal Units per hour (MM BTU/HR) were considered, with 60 MM BTU/HR being the "typical" size.

The results of the survey are shown in Table 1. Hays-Republic[2] control systems proved to be the most common, comprising 26 percent of the systems installed between 1940 and 1959, 40 percent of the systems installed between 1960 and 1974, and 32 percent of those installed since 1975. Bailey was the second most common, comprising 22 percent, 21 percent, and 19 percent of the systems in the three respective time periods since 1940. Hagan was third at 19 percent, 18 percent, and 6 percent. Honeywell and Cleveland control systems were popular in the time period between 1940 and 1959, comprising 15 percent and 9 percent of the total respectively. However, few of these two systems were reported installed after 1960. Other control systems reported were those manufactured by Cleaver Brooks, Fire-eye, Peabody, and Combustion Engineering.

[2] Hays-Republic is now a division of Milton Roy Company. The Hays Company was purchased by Milton Roy in the early 70's, and Republic Controls was purchased by Milton Roy after that. In this study, Hays-Republic includes systems manufactured by Hays, Republic and Hays-Republic, Division of Milton Roy Company.

TABLE 1
COMBUSTION CONTROL SYSTEMS
BY MANUFACTURER

COMBUSTION CONTROLS MANUFACTURER	1940 THRU 1959	1960 THRU 1974	1975 TO PRESENT	PRIOR TO 1940	TOTAL
HAYS-REPUBLIC	28	23	10	0	61
HAGAN	20	10	2	1	33
BAILEY	24	12	6	0	42
CLEAVER BROOKS	3	0	0	0	3
CLEVELAND	10	3	2	0	15
FIRE-EYE	3	5	4	0	12
HONEYWELL	16	0	3	0	19
PEABODY	3	1	0	0	4
CE	0	3	0	0	3
CEA	0	0	4	0	4
TOTAL	107	57	31	1	196

Note:
All Boiler Systems are in the 30-100 Million BTU/Hr Range

2.2 Vendor Contacts

In order to determine the specific types of control systems provided by each manufacturer, it was necessary to contact the respective vendors. Since Hays-Republic, Bailey, and Hagan were by far the most common systems, it was agreed with the Naval Civil Engineering Lab at Port Hueneme to concentrate on these three vendors, with the feeling that systems by other manufacturers would be similar in design and function.

It would have been desirable to determine the specific type of control systems employed directly from the survey. This was clearly not practical for a number of reasons. First of all, requesting such detailed information would have had an adverse effect on the response ratio of the survey simply because of the time required to complete the questionnaire. Second, the respondents would have been limited to those who had a sufficient level of understanding to provide a complete and accurate description of the control components and logic employed. Finally, evaluating such a wide variety of responses clearly could not be accomplished in the scope of this study.

From the numerous discussions that were held with the three vendors, it was discovered that defining unique control logics that could be attributed to each manufacturer was extremely difficult. No manufacturer provided a discrete system that remained unchanged during any of the three time periods under evaluation. The main features of the evolution of the various systems were in the areas of safety, reliability and sensitivity. Individual components were continually improved and updated, and systems were often custom tailored to meet the needs of the owner.

Furthermore, the basic operating logic of the systems manufactured under the various trade names were almost identical with similar optional logic additions available.

It was decided to define the common types of control systems employed, regardless of manufacturer since this approach still satisfied the intent of the study. The three most common systems were the pneumatic, electric (or electronic), and mechanical jackshaft. These are discussed in detail below.

3.0 Control System Design Concepts

The function of any burner control system is to provide the proper amounts of air and fuel to the boiler to produce the desired steam flow at the correct temperature and pressure. It is essential that fuel and air flows stay in the proper proportion, regardless of steam flow. Too much air results in inefficient operation, too little can cause incomplete fuel combustion and hazardous conditions within the boiler.

The most practical method of controlling fuel and air flow to a small boiler is to use the steam pressure as the master signal. For most systems of the type examined in this study, a single element master (namely steam pressure) is sufficient for reliable operation of the boiler. More advanced systems utilize two and three-element control, whereby the steam pressure signal is moderated with temperature and flow signal corrections. It should be recognized, however, that additional control features are available, even for small industrial boilers. These feature include safety and/or efficiency improving devices such as furnace pressure regulators, damper interlocks, and oxygen trim. These will be covered in greater detail in the next phase of this study.

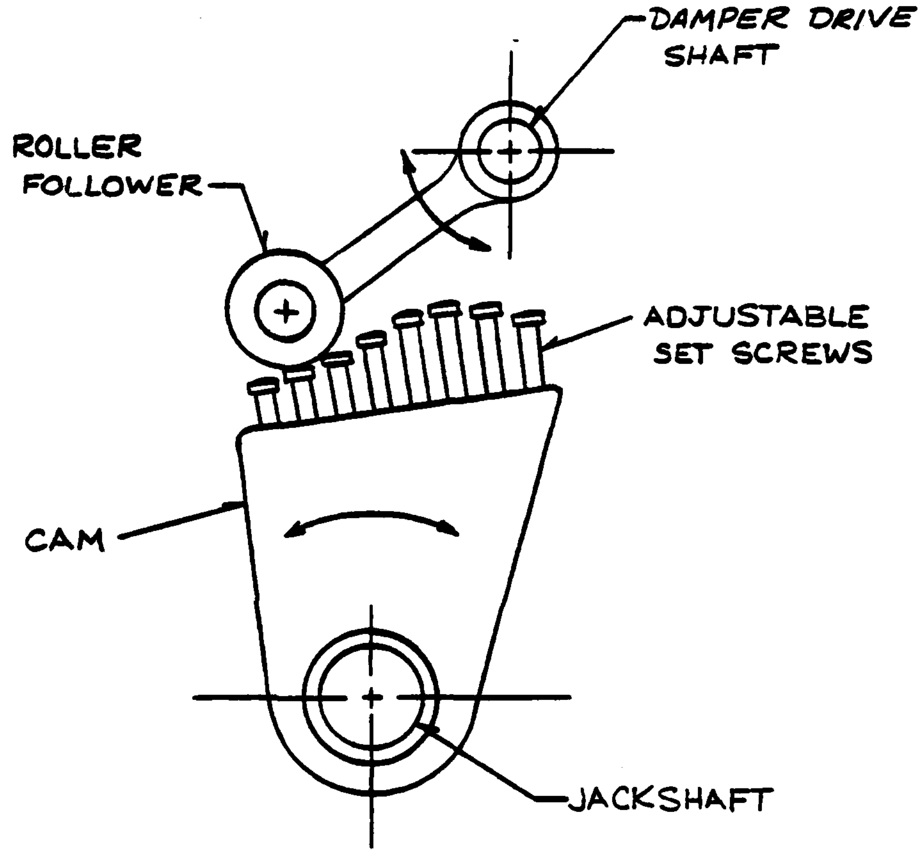
The control systems outlined below all rely on a steam header pressure signal as the master control signal. Each uses a similar control logic, but the method of achieving the desired control function differs between systems. Each is a proven technology which has many years of successful operation in the field. The choice of which system is the most desirable is dependent to a large extent on the preferences of the boiler operator.

3.1 Jackshaft System

The mechanical jackshaft burner control system is one of the most common systems utilized on small industrial boilers in the 60 million BTU/Hr range. With this type of system, the individual control components are mechanically linked to a long shaft which rotates through an angle of approximately 90^{o} or so. This shaft can be rotated either manually or by means of a drive mechanism which receives a signal from the master pressure controller. As the shaft rotates, the burner fuel valve and the combustion air damper are either opened or closed in unison.

Various means are employed to ensure that the proper damper position occurs at each fuel flow. The most common is the use of an adjustable cam and follower mechanism on either the damper drive or the fuel valve positioner (see Figure 1). With this mechanism, the ratio of fuel flow to air flow may be predetermined for any boiler output.

A functional schematic diagram for a jackshaft burner control system is shown in Figure 2. The system shown here utilizes an electric drive mechanism to rotate the jackshaft. This mechanism could also be pneumatic or hydraulic. The master pressure controller could be either an electric or pneumatic design as manufactured by Hays-Republic, Hagan, Bailey, or others. A logic diagram for the ckshaft System is shown in Figure 3.



ULTRASYSTEMS ENGINEERS AND CONSTRUCTORS INCORPORATED IRVINE, CALIFORNIA	FIGURE 1 JACKSHAFT SYS - ADJUSTABLE CAM MECHANISM	Design DBR		Checked
		Date 10/81	Job No.	Sh. No.

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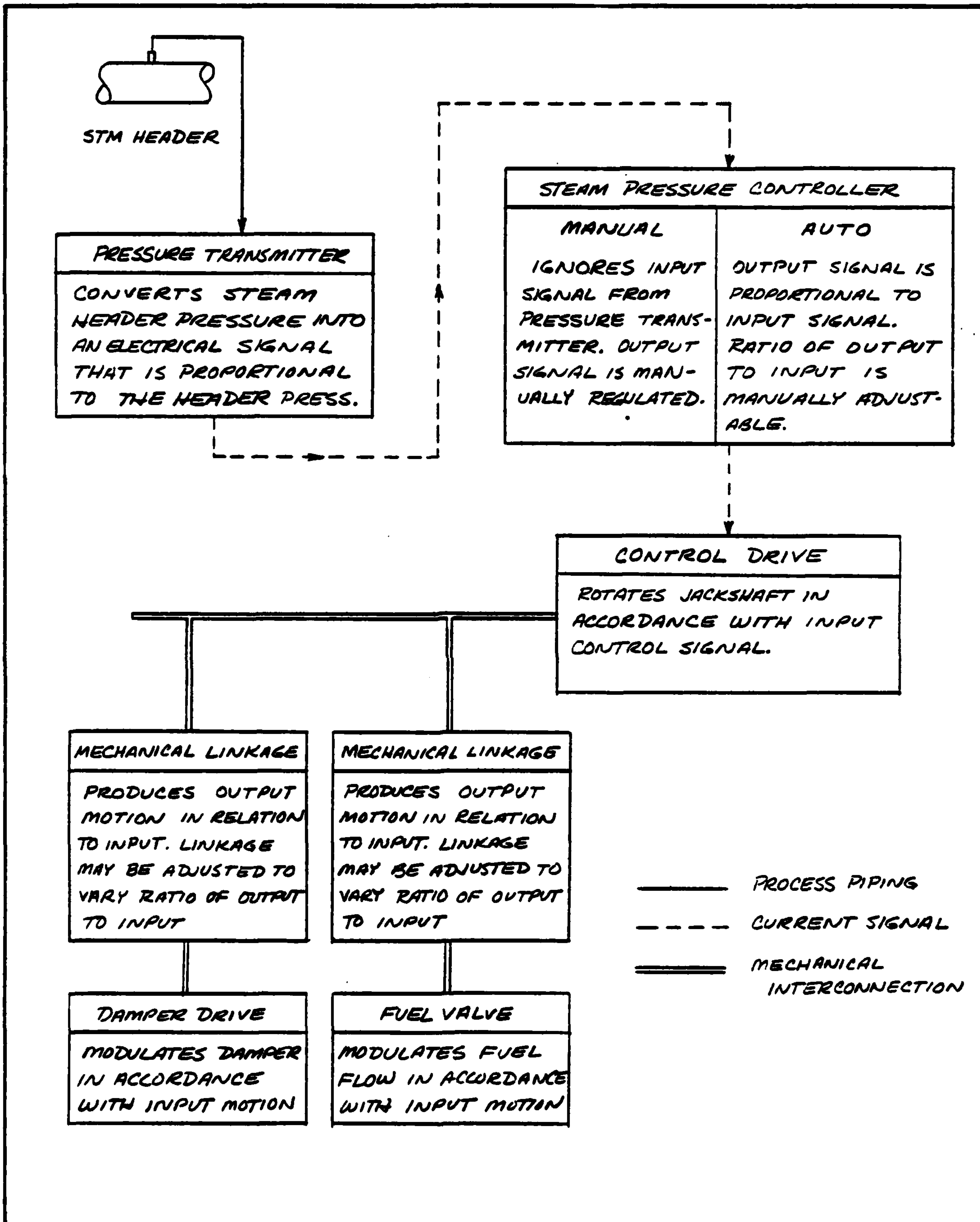

ULTRASYSTEMS ENGINEERS AND CONSTRUCTORS INCORPORATED IRVINE, CALIFORNIA	FIGURE 2 JACKSHAFT SYS - FUNCTIONAL SCHEMATIC DIAG.	Design	Checked	
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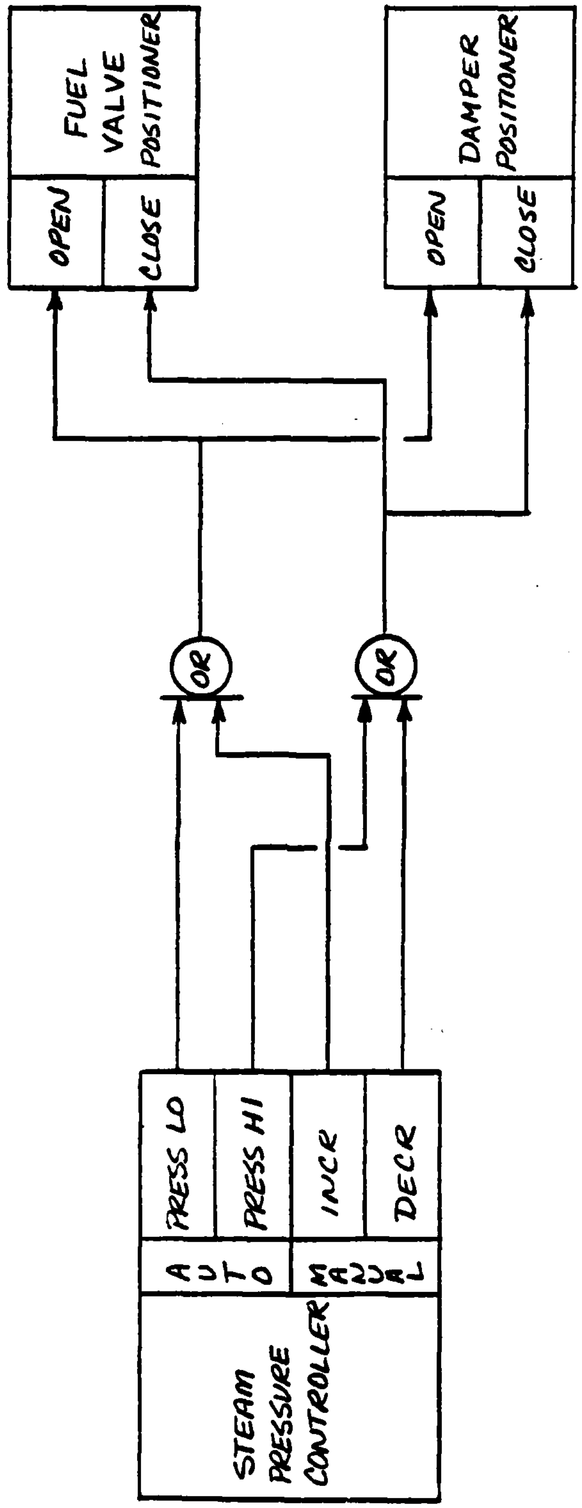

ULTRASYSTEMS ENGINEERS AND CONSTRUCTORS INCORPORATED IRVINE, CALIFORNIA.	FIGURE 3	Design	Checked	
	JACKSHAFT SYS. - LOGIC DIAG.	Date 10/81	Job No.	Sh. No.

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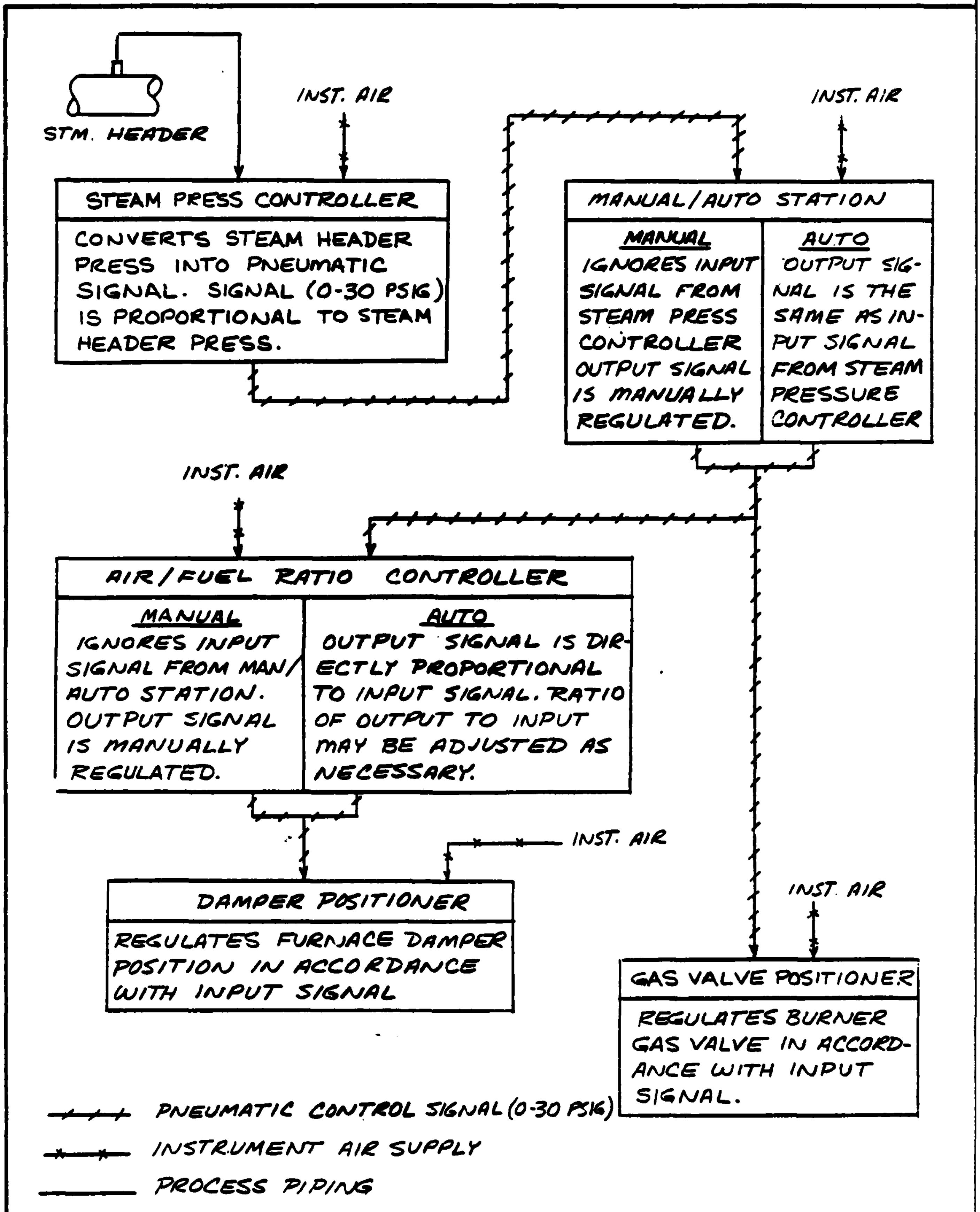
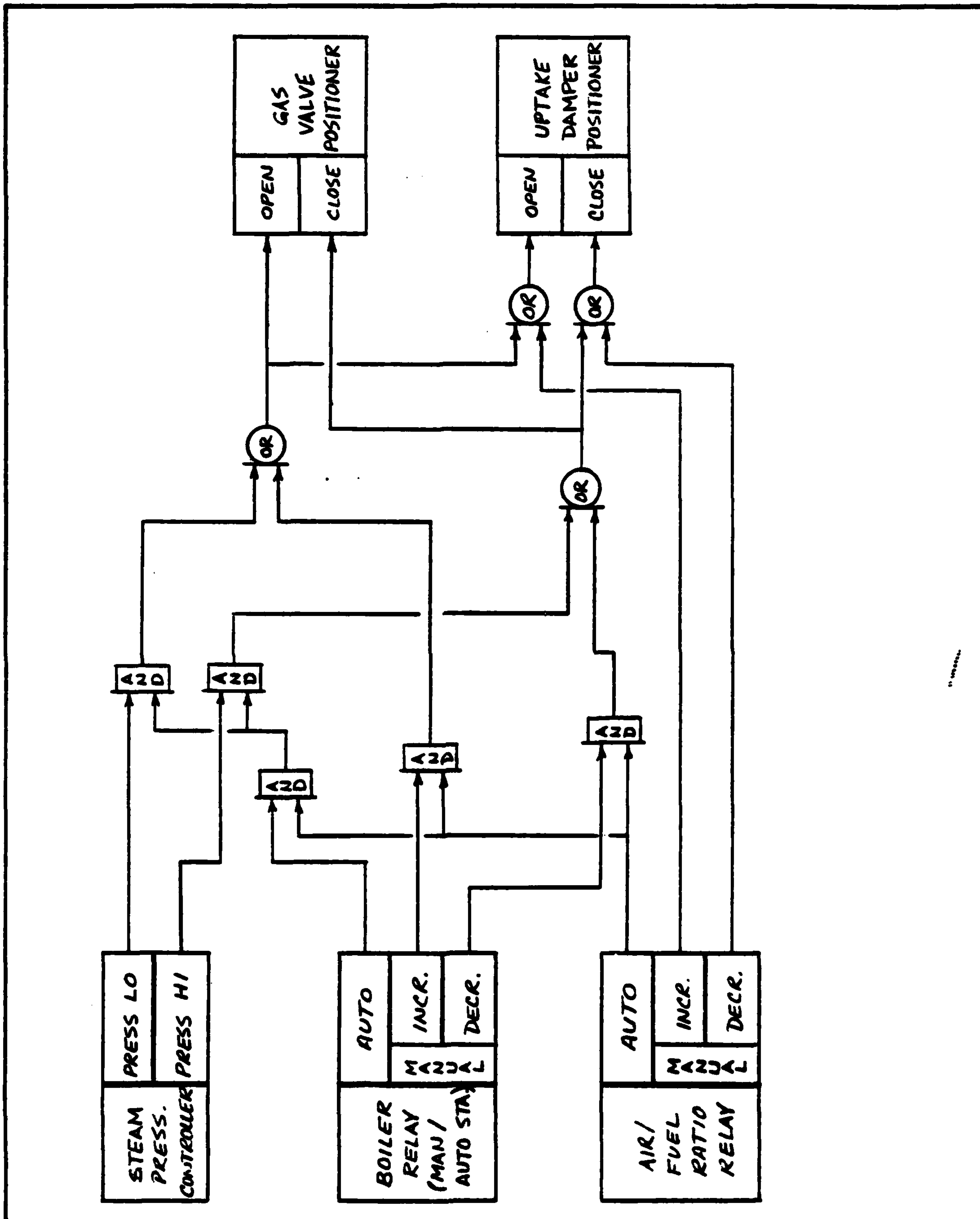
3.2 Pneumatic System

Pneumatic control systems were perhaps most often provided by Bailey and Hagan, but Hays-Republic and other manufacturers also provide similar systems. The pneumatic control system, as its name implies, uses compressed air to transmit control signals from one device to the other. Steel or copper tubing is used to interconnect the control devices, and an outsite source of compressed air is required to power the system. The pneumatic control signals are normally in the range of 3-15 psig, but control pressures ranging up to 30 psig are not uncommon.

Like other control methodologies, the pneumatic system uses a master pressure controller to sense steam header pressure, and to initiate corrective control measures when required. The control signal is normally transmitted to the damper drive and the fuel valve positioner simultaneously in what is termed a parallel positioning system. A functional schematic and a logic diagram for this type of system are shown in Figures 4 and 5. A less common approach is a series system in which the control signal is sent only to one device (either the damper drive or the fuel valve positioner). A separate control signal is then generated based upon the movement of the first device, and this signal is sent to the other drive mechanism. The preferred system uses the damper drive as the first device due to its built-in safety feature of making sure that sufficient air is available for combustion before allowing an increase in fuel flow. Other systems use a cross-limiting feature which prevents fuel flow from exceeding air supply even though the signals are in parallel. (These systems will be addressed in more detail in the Operating Manual).



ULTRASYSTEMS **ENGINEERS AND CONSTRUCTORS** **INCORPORATED** **IRVINE, CALIFORNIA**	FIGURE 4 PNEUMATIC SYS.- FUNCTIONAL SCHEMATIC DIAG.	Design [illegible]	Checked	
		Date 10/81	Job No.	Sh. No.



ULTRASYSTEMS **ENGINEERS AND CONSTRUCTORS** **INCORPORATED** **IRVINE, CALIFORNIA**	FIGURE 5 PNEUMATIC SYS-LOGIC DIAG	Design DEC Date 10/81	Checked Job No. / Sh. No.

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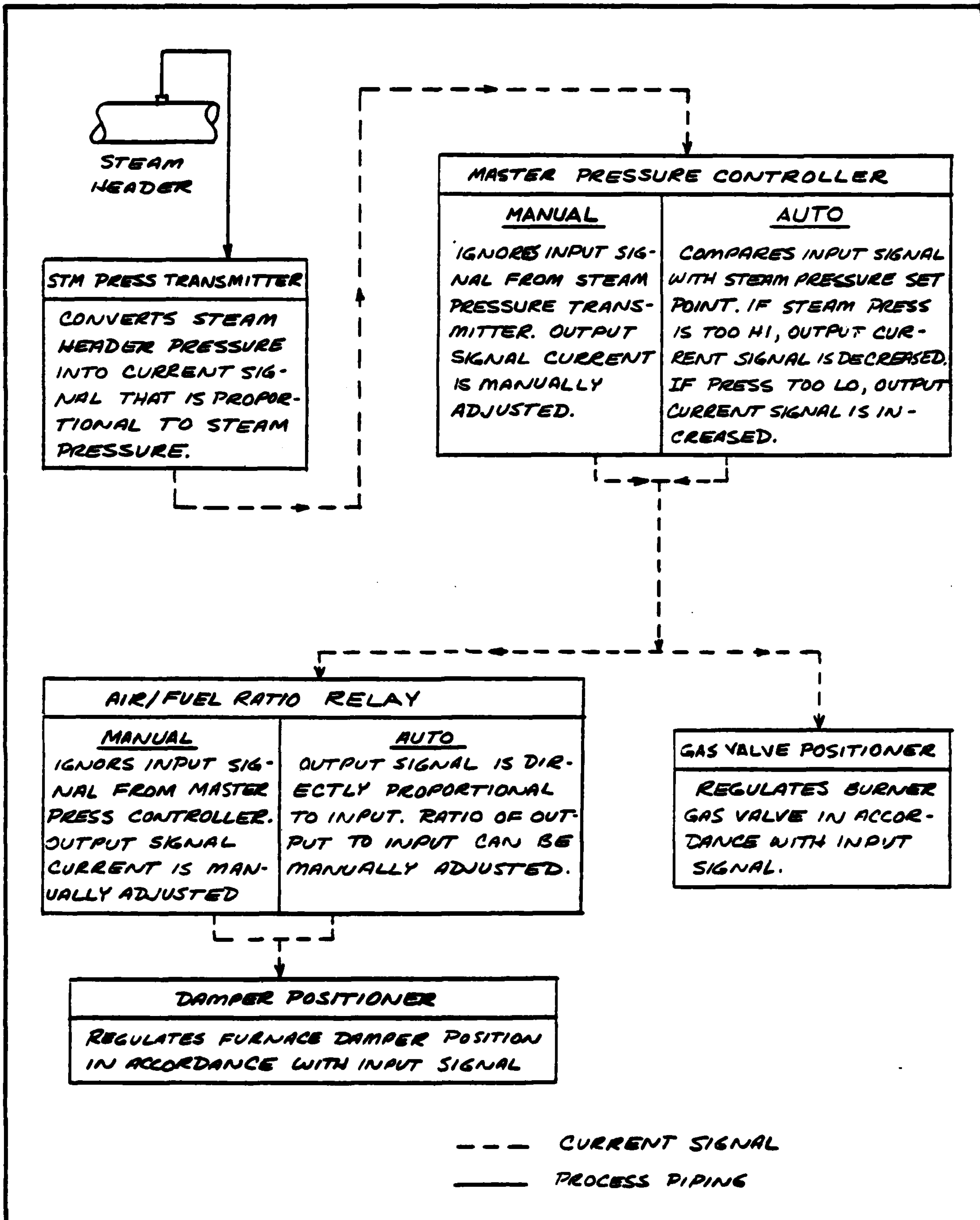
3.2 Pneumatic System, Cont.

Operating flexibility and flow control adjustment are achieved in a pneumatic control system by utilizing control components such as manual/auto control stations and fuel/air ratio controllers. The manual/auto control station is used to provide local manual control for a particular control device or subsystem. The fuel/air ratio controller is used in a parallel positioning system to provide a different control signal to the damper drive than the one provided to the fuel valve positioner (or vice versa). In this manner, the correct fuel/air ratio can be maintained over the load range of the boiler.

3.3 Electric System

The electric (or electronic) control system is perhaps most commonly associated with Hays-Republic, but Hagan, Bailey and others produce similar systems. The electric system is functionally the same as a pneumatic system, the major difference being the fact that the control signals are electric. Comparable control components are used, and the logic is similar. Electric systems normally use direct current (dc) to transmit control signals. The signals are usually in a 1 to 5 or 4 to 20 milliamp (ma) range. The operating voltage may vary depending upon the manufacturer. Voltages in the 24 vdc or 115 vdc range are the most common.

As mentioned above, the electric control system is functionally similar to a pneumatic system. As with a pneumatic system either parallel or series positioning may be used. A functional schematic and a control logic diagram for a parallel positioning electric system are shown in Figures 6 and 7 respectively.



ULTRASYSTEMS ENGINEERS AND CONSTRUCTORS INCORPORATED IRVINE, CALIFORNIA	FIGURE 6 ELECTRIC SYS. FUNCTIONAL SCHEMATIC DIAG	Design	Checked	
		Date 10/81	Job No.	Sh. No.

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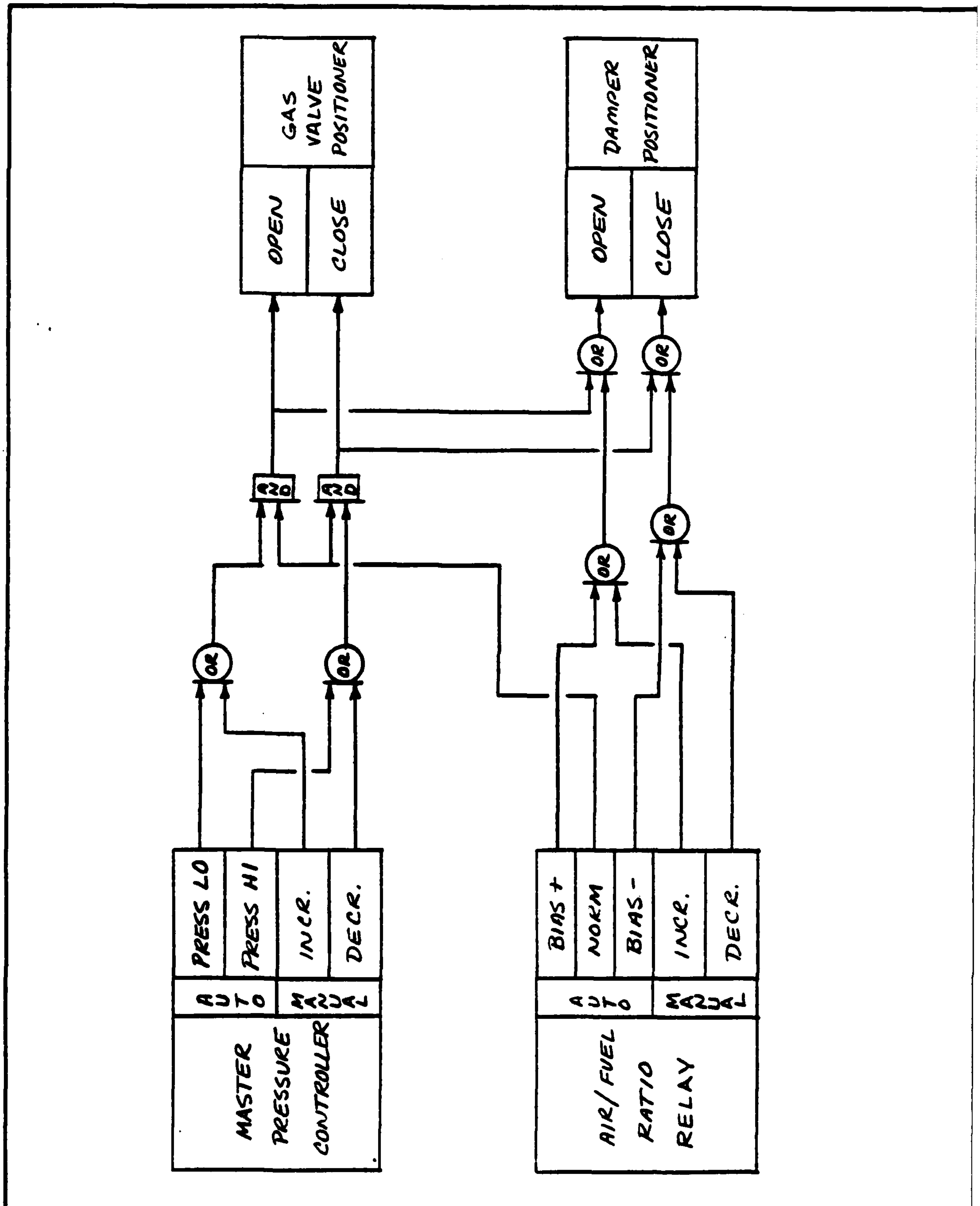

ULTRASYSTEMS ENGINEERS AND CONSTRUCTORS INCORPORATED IRVINE, CALIFORNIA	FIGURE 7 ELECTRIC SYS - LOGIC DIAG.	Design	Checked
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